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MINISTRY OF THE ENVIRONMENT
135 ST. CLAIR AVENUE WEST
TORONTO 195, ONTARIO

SELF-CONTAINED INDIVIDUAL WASTE DISPOSAL SYSTEMS

MINISTRY OF THE ENVIRONMENT
RESEARCH BRANCH

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SELF-CONTAINED

INDIVIDUAL

WASTE DISPOSAL SYSTEMS

By

A. V. Giffen

RESEARCH BRANCH

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Ministry of the Environment
135 St. Clair Avenue W.
Toronto 7, Ontario

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SUMMARY

This report was prepared, based on available literature, to define current technology concerning self-contained individual sewage disposal systems for use primarily in the cottage country. The report indicates that the standard septic tank, soil absorption system is satisfactory in areas where soil conditions are suitable. For other areas with impervious soils or otherwise unsuitable conditions where this method has not been completely successful, it is indicated that alternative systems are available.

For areas where the discharge of wastewater to the soil is unacceptable, total storage and haulaway appears to be the most practical alternative available that will ensure safe disposal practices. Storage and transport costs for a total storage and haulaway system are directly related to the volume of waste produced and, therefore, the installation of water saver devices is an important consideration if this type of disposal system is to be utilized economically. Also, it would be necessary to establish haulage services to transport stored wastes and regional areas for the centralized disposal of wastewater collected from these systems.

TABLE OF CONTENTS

I INTRODUCTION

In regions where municipal sewage collection and treatment systems are not practicable, for financial or other reasons, the most widely used sewage treatment process for individual dwellings has been treatment of domestic wastes in septic tank, soil absorption systems. This process and related systems have been and will continue to be satisfactory in areas with suitable types of soils, topography, and other favourable factors.(6) There are areas in Ontario however, particularly in the cottage country, with inadequate soil or otherwise unsuitable conditions where the discharge of waste water and septic tank effluents to the soil by way of tile beds or seepage pits has not been permitted. Dissatisfaction with the septic tank, soil absorption method and with related methods in their present state of development has been indicated by private individuals, cottage associations, the Ministry of Health and the Ministry of the Environment. For those cottages now located on unsatisfactory soils or for proposed building plans involving wet soils, alternative self-contained individual sewage disposal systems should be considered.

This report was prepared, based on available literature, to define the present state of the art concerning self-contained individual sewage disposal systems primarily for use in the cottage

country, to indicate where additional information is required and to show those areas of investigation where research might be carried out to further improve such installations. Much of the data presented in this report is based on information obtained from a report on the development of individual sewage disposal units prepared for the National Association of Home Builders Research Foundation, Inc., by Engineering Science, Inc.(1)

II DOMESTIC WATER CONSUMPTION AND CLASSIFICATION OF DOMESTIC USE

Previous studies indicate that per capita domestic water consumption is related to the number of persons in the household, with per capita consumption decreasing as the household increases in size. In Table II-1 (1), the rate of increase per dwelling increases rapidly to a household of five persons. Thereafter the incremental change levels off. A family of five will probably represent the "average" household population. The data indicate that a five member family may represent a conservative number to consider when determining single dwelling domestic water consumption.

Table II-1

METERED WATER USE

Persons Per House	Average igpcd	Average Dwelling igpd
2	44	88
3	34	102
4	28	112
5	29	145
6	25	150
7	23	161

Because of the importance of water quantities in the planning of water and waste treatment facilities, the literature contains many design estimates for the daily per capita water use. Relatively few reports have been published on actual water usage

in individual households and the distribution of the water among the various uses. This is particularly true for cottage systems. The figures most widely reported are between 33 and 66 imperial gallons per capita per day (igpcd). United States Public Health Service studies to develop design criteria for soil absorption systems, revealed that the average daily water use for cottages and small dwellings with seasonal occupancy was 33 imperial gallons per person (2). In 1968 the Ontario Department of Health conducted a study on water usage in the cottage country during which they individually metered the fresh water supplied to 19 cottages. The average daily water used was 12 imperial gallons per person and ranged from a low of 4.5igpcd to a high of 39igpcd (3).

The water delivered to the households is divided among the various uses in a different manner in every household. A few of the published estimates of water use quantities are listed below.

Household Water Uses (4)

Type of Use	Percentage
Toilet Flush	45
Bathing	30
Kitchen	6
Drinking	5
Laundry	4
Miscellaneous	10

Estimated Distribution of Sewage (2)

Waste	Volume of Waste, igpcd			
Tot. Flow (gal.)	25	33	42	55
Kitchen Wastes	0	6	8	8
Toilet Wastes	12.5	12	17	17
Showers, wash basins, etc.	12.5	15	17	17
Laundry Wastes	0	0	0	13

Waste Water Flows (5)

Source	igpcd
Kitchen	11
Showers and Lavatory	14
Laundry	2
Toilets	6 (vacuum toilet 5 flushes)

For the purposes of this report an "average" cottage, established as a standard of comparison to which all methods for waste treatment or reduction of waste flow can be compared, is a three bedroom structure with one bathroom, having a shower and tub or a shower - tub combination. The cottage has a washing machine but does not have a dishwasher or a garbage disposal unit. The "average" family occupying this "average" cottage will consist of two adults and three children who will use water in the "average" way.

In the "average" cottage, the water requirement per person is set at 40 gallons per day which is probably a very liberal amount. The various uses are broken down as follows: 3 for kitchen, 12 for bathing, 2.2 for drinking, 1.8 for laundry, and 20 for toilet flushing. The water usage quoted for bathing (13 igpcd) is probably an inflated figure in that the average cottager more often bathes himself in the lake than in the tub or shower.

III TREATMENT PROCESSES WITH AN EFFLUENT

ANAEROBIC TREATMENT

1. Septic Tank

The septic tank, soil absorption system is the most commonly used individual waste disposal system. The use of pit privies and cesspools, two of the oldest sewage disposal methods, is diminishing and in general they have been replaced by septic tank systems which permit the use of flush toilets and running water. It should be noted though, that many of the comments on soil absorption systems apply also to pit privies and cesspools.

The septic tank disposal system consists of a tank in which to collect and digest sewage solids and a soil absorption system from which the effluent percolates into the ground. The septic tank system has no moving parts and the only maintenance required is the removal of solids which resist anaerobic decomposition and slowly accumulate in the tank. Because the effluent is not amenable to direct surface discharge, conventional disposal of the effluent from the septic tank has been by percolation through the soil by way of tile fields or seepage pits. Consequently, any nitrogen and phosphorus compounds in the effluent are potential ground water contaminants and, as such, also potential surface water contaminants.

The primary objective of the septic tank is the removal of suspended solids by sedimentation, and the storage and digestion of the settled matter. As the wastewater enters the tank the heavy solids begin to settle to the bottom and the lighter materials, greases and oils, float to the surface. All of the free-dissolved oxygen is used up in the first hour. Anaerobic bacteria, in the absence of dissolved oxygen, decompose some of the non-settleable suspended solids, with the consequent production of gases and the breaking up and partial liquefaction of the solid organic matter.

The liquefied solids and dissolved organic matter then pass with the effluent to the soil absorption system where a combination of physical, chemical and biological reactions provide additional stabilization. The effluent from the septic tank is anaerobic, usually neutral in pH, and accordingly may be odorous.

The soil system is probably the most important and expensive, and the most neglected part of the septic tank, soil absorption system. It is in the soil that the remaining nutrients in the septic tank effluent must be removed and the remaining solids and micro-organisms filtered out before the percolating water reaches the ground water. The soil absorption system is the capacity limiting factor of the system since wastewater

cannot be discharged through the septic tank faster than it can be absorbed into the soil absorption system. If the soil cannot absorb the septic tank effluent as fast as it is applied, the excess sewage must either back up into the cottage waste system or break through to the ground surface. This is commonly referred to as ponding.(1)

The cost of a septic tank, soil absorption system cannot be accurately estimated unless the absorption system design, soil conditions, type of cottage and labour costs, are known. For the purposes of this discussion, the assumption is, as mentioned in the section on water consumption, a three bedroom cottage with a five member family, a theoretical design life of 20 years for the soil absorption system and average cost figures. Based on a water usage of 40 igpcd, the waste water flow to the disposal system then amounts to approximately 200 gallons per day.

In a soil with poor permeability, approximately 2,000 square feet of soil interface costing approximately $1,600 to $2,400 would be required. For a fair soil, only 940 square feet at $1,100 to $1,300 would be needed. In good soils, 240 square feet at $700 to $900 may be sufficient. The standards recommended by the Ontario Department of Health require in a good soil a minimum of 225 square feet absorption area in trenches 18 inches

wide which would require approximately 900 square feet of surface area (50 feet x 18 feet). Assuming a $15 per year maintenance charge (cleaning every 3 years), the annual cost for waste disposal would then be $125 to $165 in poor soils, $70 to $110 in fair soils, and $55 to $60 in good soils (Basic data from references 2, 6 and 7). These costs are approximately equivalent to a cost of 0.15¢ per gal. in poor soils, 0.10¢ per gal. in fair soils, and 0.06¢ per gal. in good soils.

Since the septic tank process is widely used, it can provide a baseline for costs of self-contained individual disposal systems to be considered henceforth.

AEROBIC TREATMENT

1. Extended Aeration

Packaged extended aeration units are available from a number of manufacturers for individual cottage use. The extended aeration system consists essentially of an aeration section and a settling section. In the settling chamber the suspended matter is separated from the effluent by gravity settling and the settled sludge is returned to the aeration chamber by gravity or mechanical means. The purpose of extended aeration periods (usually greater than 24 hours) is to increase oxidation while simultaneously

minimizing the net production of solids. There is a tendancy however, for non-biodegradable and inert waste constituents to build up to an unstable level and, unless provision is made to periodically remove solids from the system, solids inadvertently discharge with the effluent.(1)

These units are available in a size range suitable for a single cottage or a group of cottages. The cost per cottage decreases significantly as the number of cottages increases. For example, the cost per cottage for serving one cottage is $1,800 while the cost per cottage for serving five cottages is $750. Annual operating costs average in the range of $55 to $150. These costs are based on typical prices for packaged extended aeration units obtained from material prepared by the manufacturers.

The major disadvantages to the packaged extended aeration unit include: (1) the degree of competence required for efficient operation. Like any biological system it is sensitive to a number of parameters and unless these are understood by the operator, changes can upset the treatment process, (2) the operating costs are high due to power requirements and maintenance labour, and (3) because the effluent from the extended aeration plant is not of sufficient quality to permit direct surface discharge, additional

treatment would be required to disinfect the effluent and to remove nutrients. Similar to the septic tank system, disposal of extended aeration plant effluent would likely be by percolation to the soil. These units therefore would only be acceptable in areas where septic tank, soil absorption systems are acceptable i.e. where soil conditions are adequate.

A major advantage claimed for the aerobic effluent compared to the septic tank effluent is its lesser clogging effect in soil absorption systems (6). In contrast, other studies have not clearly substantiated claims for a greater soil absorption capacity with aerobic effluents (5). Since these units would likely replace septic tanks, additional research is required to clarify the effect of a higher quality effluent on a soil absorption system.

2. Sand Filtration

The Ministry of the Environment, Private Sewage Disposal Branch, has been carrying out a study at Whitby since 1969 as part of an overall project designed to study wastewater disposal units for individual buildings and houses. The main objective of the Whitby study, where septic tank effluent is being applied to a series of surface sand filters, is to develop more practical design specifications for the construction of septic tank effluent

disposal systems. A second objective of this project is to develop alternative methods for the disposal of wastewater for locations where the soil conditions are considered to be unsuitable to biodegrade and renovate septic tank effluents.

In addition to treating septic tank effluents, sand filtration has been used to treat aeration tank effluents prior to ultimate surface disposal. When the filter is properly operated, a high quality discharge has resulted with clear, colourless effluents containing dissolved oxygen and no settleable solids.(1) Bacterial removals frequently exceed 98 percent, and effluent BOD and suspended solids concentrations are normally below 10 mg/l. Using typical leaching rates, a domestic discharge of 200 igpd would require the equivalent of 175 square feet of filter surface.

Operation of sand filters requires intermittent dosing and routine maintenance to prevent clogging.(1) The filter should be enclosed to prevent undesirable access, and its above-ground location may be aesthetically undesirable. The filter is susceptible to freezing in the winter, but it can be used with special preparation for cold weather conditions.(1)

Sand filters do not remove nutrients, and because sand filtration is used only with surface effluent discharge, the health, aesthetic and nutrient enrichment problems of effluent disposal by surface discharge remain.(1)

3. Chemical Treatment

One method of replacing the action of soil can take the form of chemical precipitation, filtration and disinfection. Lime, alum or ferric chloride can be used to coagulate suspended and colloidal solids and to precipitate phosphorus compounds prior to sedimentation or filtration. The settled or filtered effluent may also be passed through an adsorption - filtration unit with activated carbon to remove odour, colour and remaining organic nitrogen compounds prior to disinfection and subsequent surface disposal.

Chemical waste treatment techniques are relatively inexpensive when applied on the scale of municipal WPCP or multiple dwellings such as apartment buildings, hospitals etc., but become increasingly costly in small installations because of the chemical handling costs and the supervision required. To date, few automatically controlled systems have been marketed for individual dwellings. The initial cost of a packaged chemical treatment unit should compare with the cost for packaged extended aeration units.

The Ontario Research Foundation, through funding by the Central Mortgage and Housing Corporation, has developed a "chemical" process to remove phosphorus from either septic tank effluent or

settled domestic sewage without the nuisance of handling chemicals (8). Aluminum electrodes are immersed in the wastewater and an alternating current is applied across them. Under the influence of the electricity, aluminum ions go into solution and immediately react with the water to form aluminum hydroxide. This reacts with orthophosphate, precipitating it out of solution. This process is still in the development stage and more research must be done before the real potential of this technique can be evaluated.

IV TREATMENT PROCESSES WITH NO EFFLUENT

CLOSED TOILET SYSTEMS

Several types of closed toilet systems which effectively eliminate liquid discharge from the toilet source are commercially available. Based on figures presented previously, the water use for toilet flushing amounts to an estimated 45 percent of the total domestic use. Table IV-1 indicates the percent of the total household waste constituents represented by the toilet wastes. This also

Table IV-1

COMPARISON OF FECES AND URINE WASTES QUANTITIES TO TOTAL HOUSEHOLD WASTES FOR A FAMILY OF 5 PEOPLE (9)

Parameter	Urine & Feces Contribution gm/day	Total Household Contribution gm/day	Percent Urine & Feces Contribution of Total
NH_3 - Nitrogen	62.0	60	100
Total Nitrogen	65.0	76.5	85
Total P	4.8	20.7	23
Total Fat	22	30.7	71
Total Solids	360	950	38

would represent the percent efficiency of the closed toilet systems in removal of these parameters. This varies from a low of 23 percent total phosphorus removal to a high of 100 percent NH_3 - Nitrogen removal. The remaining wastewaters from the cottage,

which are derived from the kitchen, wash basin, shower or tub, and in many cases laundry, must be separately processed for disposal.

1. Continuous - Aeration, Closed-Cycle Flush Toilet

This unit consists of a toilet bowl and one or two tanks in which the contents are continuously aerated. The aeration tank liquor is used for flushing. The flush liquid is usually odourless, but objectionable odours may develop if the system is overloaded.

Extended aeration units with recirculation of the aeration tank contents solely for flushing purposes are available with a variety of post-treatment systems designed to make the recirculated flush liquid more acceptable. The most common post-treatments are disinfection of the effluent from the aeration chamber and removal of the suspended solids by filtration. Chlorine, ozone, and other chemicals, as well as pasteurization, have been suggested for disinfecting the recirculated flush liquid. In one system, the effluent from the aeration step is filtered through a particulate and carbon adsorption filter and then reused as a toilet flushing liquid.

With the closed toilet, the recycle of flushing water following extended aeration treatment has serious health and aesthetic limitations. Failure of the extended aeration or disinfection processes through lack of maintenance, improper operation,

or power failure may either shut off completely the flow of flushing liquid to the toilet, or else produce an inadequately treated effluent of potential or existing health hazard.(1) There is the risk that children may accidentally come into contact with flushing liquid in the bowl. Furthermore, discolouration of the flushing liquid results from extended recirculation due to accumulation of biologically resistant materials. Scum, foam, and discolouration of the toilet bowl are the general rule in these systems.(1)

2. Incinerator Toilets

These units provide complete gas incineration of toilet wastes to an inert ash. Normally they use no water for flushing but can handle up to a quart of liquid material. The combustion time is from 14 to 40 minutes, but the combustion cycle can be interrupted at any point for subsequent usage of the unit. Combustion vapours are vented to the atmosphere. Operation is completely automatic and the toilet becomes nonusable when it is not functioning properly.

The cost of these units, including installation, ranges from \$350 to \$600 depending on the type purchased and the extra features desired. There would also be the cost of gas and electricity which may be significant, especially in cottage country.

The primary advantages of these devices include: (1) complete removal of fecal and urine wastes, and elimation of most of the public health hazard from cottage wastes, (2) easy installation and maintenance, and (3) assured quality control if properly installed since there is no place for the waste to go if the unit is not operating. Adequate maintenance and operation is essential.

The primary disadvantages of the units include: (1) these units are not designed to destroy odours and, thus, create an odour nuisance, (2) corrosion of valves and other moving parts is a problem, and (3) these units do not provide adequate treatment for the total cottage waste in that treatment is provided only for toilet wastes.

3. Chemical Toilets

Chemical toilets are in general use in the mobile home, marine and summer cabin applications because of the small volumes of flushing water required and the simplicity of plumbing.(1) The earlier chemical toilet has a straight drop into a large steel tank in which lye is added to reduce the solids to liquids, and completely eliminate sewage odours.

In a modification of this unit the liquid, dyed blue or green, is used for flushing. The only maintenance required

is a cleanout at regular intervals and intermittent chemical addition. One company offers a water closet which recycles disinfected flushing water and reportedly collects and stores wastes from 80 to 100 uses when primed with only four gallons of water (5).

The principal objection to the chemical toilet is aesthetic because of the odour problem (1) and the nuisance of removing and disposing of the collected waste. The chemical toilet with a discharge pump can be purchased for approximately $300 and can be operated for about $0.01 per flush including disinfection (a yearly cost of $20 per person). Tests indicate that the chemical used for disinfection does not hinder either anaerobic or aerobic treatment of the collected wastes (5). Again, as with the other closed toilet systems, the disposal of the other cottage wastewaters remains a problem.

<u>PARTIAL REUSE OF WATER</u> (1)

The partial reuse of water to reduce domestic effluent might take two forms:

1. Internal reuse of non-sanitary household waste, such as from showers and tubs, for toilet flushing.

2. Recycle of a fraction of the treated effluent from the entire cottage solely for toilet flushing purposes.

Either scheme is capable of reducing domestic sewage volumes by the quantities required for toilet flushing.

Reuse of non-sanitary cottage wastes for sanitary waste disposal presents some direct objections. The strict definition of sanitary and non-sanitary wastes is difficult to apply because shower or tub drainage may contain urine, sink phlegm, and laundry waste fecal matter from diapers, etc. In addition, foam or scum formation in the toilet bowl or tank would be aesthetically unacceptable as would the formation of odours in the bathroom from the flushing fluid.

Consequently, the reuse of non-sanitary cottage wastes would require prior treatment. For the second suggested scheme, the recycle of a portion of treated effluent for flushing purposes, essentially the same objections exist when partial recycle of treated effluent is considered as with the total recycle discussed earlier. Principally these are operational, aesthetic and publich health problems.

COMPLETELY CLOSED SYSTEMS

The Ontario Research Foundation, under a contract with Central Mortgage and Housing Corporation, is carrying out research to develop "a completely closed domestic water system which will render a high density population free from water input

pipes, used water output pipes and household refuse or garbage output, without producing air pollution and, to collect sufficinet engineering data for smaller or less dense popluation units" (10).

This unit will likely consist of extended biological oxidation in a trickling filter or activated sludge unit followed by sand filtration and reverse osmosis. The permeate would be used and recycled and the concentrate would also be recycled to many of the problems are unresolved.

TOTAL STORAGE AND HAULAWAY

Collection and storage of wastes for delivery to a common disposal site has been practiced by airlines and some watercraft for years. In the case of a cottage the entire wastewater flow would be stored until it could be disposed of.

Tanks of 2,500 and 10,000 gallon storage capacity could be placed in a remote area of the cottage lot and easily provide twelve days storage or more for the normal cottage (200 igpd sewage flow). According to a schedule, this depending on the tank capacity and daily sewage flow, the storage tank could be pumped out and the contents hauled to the nearest WPCP. Fail-safe devices, such as an automatic fresh water supply shutoff, would need to be provided in case the storage unit

approached its capacity. During storage the biological activity in the tank would be similar to that in a septic tank and ventilation would have to be provided for. (1)

The principal cost factors would be the waste pumping, transport and final disposal cost at the WPCP. Of these, transport and disposal cost appear to be the more difficult to estimate. Obviously, as the volume to be disposed decreases, the time between dumping increases and the economy is greater. Consequently, water conservation and flow reducing devices are important considerations if this type of disposal system is to be utilized economically.

V REDUCTION OF WATER USAGE REQUIREMENTS

Previous studies indicate that reduction of water usage appears to be economically the most feasible means of reducing waste flow from individual dwellings (5). The conventional household and cottage water closet uses 3.5 to 5 gallons of water per flush and flushing water can amount to more than half of an individual's daily water usage (11). The amount of water required for flushing is governed by design and aesthetic criteria for sufficient water to effectively remove the wastes from the toilet. By redesigning the toilet bowl and the water trap various manufacturers are producing toilets which, they claim, require from as little as 1 quart of water to less than 3 gallons of water for an adequate flush, thus reducing the "average" individual's requirements by as much as 85 percent per flush or about 10 to 12 gallons per person per day. (5)

1. Toilets with Separate Flush Cycles

The British have developed a dual cycle water closet, one flush cycle for urine, the other for solid wastes (5). The water closets operate on a syphon system with a very shallow trap seal. The flush for solid waste is 2 gallons and the urine cycle uses only 1 gallon. This dual cycle water closet would provide a 70 to 75 percent reduction in water usage as compared to the conventional toilet. However, it should be noted that the British design may not

meet the requirements of the OWRC plumbing code and revisions may be necessary.

2. Vacuum Toilet

A relatively new development in water closets is the Liljendahl system (Swedish) which is being investigated in the United States (5). This system uses air rather than water as the transport fluid and requires about one quart of water per flush. Plastic pipe is used for the drain lines, and a waste receiving tank and vacuum pump are needed. A vacuum flush toilet for a single dwelling costs approximately $1,500 (5).

3. Faucet Flow Reduction Devices

Several manufacturers currently market limiting flow valves that restrict the maximum flow rate (5). These valves provide maximum water savings with showers although they can also be used in kitchen and bathroom sinks.

For shower heads, the flow rate with a limiting flow valve is usually restricted to about 2.5 igpm. For bathroom and kitchen sink fittings, the flow is usually restricted to about 2.0 igpm for each valve. Water savings of 50 to 70 percent are claimed, but independent test data for households are not available. Generally, though, the quantity of water saved will be dependent on many factors, including the water pressure available and the habits of the user.

VI. DISCUSSION

An attempt has been made to review all the information that is available on self-contained individual sewage dispoal systems both in terms of technical capabilities, and in terms of health, aesthetic and economic factors. Since subsurface disposal by soil percolation is not acceptable in many areas, it is important to eliminate all health hazards and to minimize aesthetic and psychologic aspects that may be associated with alternative methods of waste disposal. Likely of greater concern to the owner would be the health and aesthetic aspects resulting from the presence of recycled treated effluent in his cottage. The potential health hazards resulting from improper treatment or temporary disinfection cannot be over emphasized. Because of the weaknesses associated with recycle it is questionable that this approach has any immediate research potential.

The reduction of water usage appears to be the most feasible means of reducing waste flow from the cottage. There are many cottage functions in which water is used 'wastefully'. Water for bathing and toilet flushing can be reduced approximately 50 percent by use of presently available devices and technology. In the "average" cottage these savings could amount to more than 6,000 gallons of water over the two month summer vacation period,

assuming continued usage. Whatever the method of treatment for individual cottages or groups of cottages, handling and treatment of the wastes should be more efficient and less expensive when it is concentrated in a smaller volume. For example, storage and transportation costs for a total storage and haulaway system are directly related to the volumes of waste produced. Thus, water economy is an important consideration if this method of disposal is to be utilized economically. Also, it is expected that the wastewater from systems where water saver devices are installed will be relatively strong when compared to conventional domestic sewage and it may be necessary to develop new treatment systems designed specifically to treat these wastes.

Another means of reducing waste flow from the cottage would be the use of closed toilet systems e.g. incinerator toilets. It has been indicated however, that with these units treatment is provided only for toilet wastes and the disposal of the other cottage wastewaters remains a problem.

Advanced waste treatment schemes other than filtration and disinfection are generally not practicable for a normal cottage. Most cottage owners could not meet the initial and operating attention required by many of the advanced treatment

systems. Chemical treatment processes are continually being improved on and may provide the best alternatives to soil absorption systems in high density cottage areas. A modified Liljendahl vacuum system used in conjunction with the chemical treatment method could make this an even more economically attractive alternative. The Liljendahl vacuum sewerage system may be installed without regard to topography and grades and uses inexpensive, easily laid piping, usually 2 inch diameter PVC. Since most cottages are used only during the summer vacation periods it would not be necessary to bury the sewerage system which, under the best conditions, is an expensive proposition.

Total storage and haulaway appears to be a feasible means of waste disposal for individual cottages located in areas with impervious soils or otherwise unsuitable conditions where the discharge of waste water to the soil is not acceptable. Before such a system could become operational however, a scavenger truck service to transport stored wastes and regional sewage treatment facilities for the disposal of wastewater obtained from storage and haulaway systems would have to be established. Motor driven barges could be a very attractive solution to the haulaway problem for islands and otherwise inaccessible areas.

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